Numerical modeling of flow in fractured porous media and fault reactivation

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Keywords. Fractured porous media; Frictional contact.

The study of flow in heterogeneous and fractured porous media finds application in several fields, from material science to bio-medicine, and geophysics. In the last here we have investigated several numerical techniques to describe flow in porous media in the presence of fracture networks, mainly with applications in subsurface flows.

Fractures in the subsurface are present with a very large variation of spatial scales, they may form complex networks and influence the underground flow considerably.

A common characteristic of fractures is the fact that their width (technically called aperture) is much smaller than the other dimensions. Therefore, it may be convenient to model them as as one-codimensional manifolds immersed in the porous matrix rock, possibly forming a network. We have then a coupled differential problem formed by the equations for the flow in the rock matrix and a reduced model posed on the tangential plane of the fracture. The model is completed by suitable coupling conditions describing the mass flow interchange between fracture and rock matrix and, in the case of networks, coupling conditions at the fracture intersections. We will review some recent results concerning the properties of numerical schemes for this class of problems.

In the case of faults, alteration of the flow field due, for instance, human activity, may alter the stress distribution and cause the risk of (micro)seismic activity (fault activation). In this situation the flow problem has to be coupled with a mechanical model of the rock, giving rise to a Biot model, and a frictional model to account the possibility of fault slip. We will present recent studies of a technique based on the minimization of a non-linear functional that allows to impose the friction condition without resorting to Lagrange multipliers.

References

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